Visualizing Public Transportation Arrivals

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ABSTRACT
Public transportation time schedules are often littered with extraneous data irrelevant to passengers who only seek the next immediate arrival. We explore how the inclusion of visual encodings in time schedules allows users to easily identify and determine the fastest routes to their destinations. We present this solution in the form of a visualization system in which users select their point of origin and are then presented with a visualization of upcoming arrivals at that particular station. We report the results of user studies of our system, observing the complementary role of information visualization towards human comprehension of these time schedules.

Author Keywords
Information visualization; design; transportation visualization

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Human Factors; Design.

INTRODUCTION
According to the American Public Transportation Association, 10.5 billion trips were taken on United States public transportation in 2012, making it the second highest ridership year since 1957. For the average daily commuter, the time spent waiting idly can be considered to be relatively insignificant. However, the cumulative waiting time of all those passengers on each of their respective trips translates to a huge loss in productivity.

The proliferation of modern day mobile and web applications that allow users access to real-time schedules at the touch of several buttons has somewhat managed to alleviate this issue. Nevertheless, these applications assume that the user is familiar with the concerned transportation network and is able to navigate it easily. This factor as well as the other disadvantages to the existing system served as motivation for us to design a new approach to how passengers read and comprehend arrival times.

To gain a better sense of the rationale behind our design decisions, we take a step back to examine the principles involved within visualizing a transportation network. Harry Beck’s redesign of the London Underground’s route map from its geographic form into a series of straight lines showcases a technique used to emphasize information without coming at the expense of too much accuracy. The ideal representation of our system would be one that visualizes arrivals moving along a network’s routes.

In this paper we present a visualization system that addresses the shortcomings of existing public transportation time schedules. It is structured as follows:

We will first examine related work as well as common transportation visualization techniques. We introduce our system and its interface, followed by its implementation details. We then present the results and conduct a preliminary evaluation of our approach.

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RELATED WORK

Modeling a Public Transport Network for Generation of Schematic Maps and Location Queries
Avelar and Huber design a process for automatically generating schematic maps. They designed a data model for geographical and topological information of a public transportation network. It is built for the general case and can be adapted to any basic network model that has linear features. In addition, they utilize a database containing topological information to support common queries. This tool also provides basic data visualization capabilities.

Figure 2. User interface that provides location queries to obtain lines, stations, reference places by name or geographical location.

Automatic Metro Map Layout Using Multicriteria Optimization
Stott. et al. describe a mechanism for automatically generating metro map layouts. They apply multicriteria optimization to find effective placement of stations with good line layout and to label the map in a clear and obstructive manner.

Transporter
The Transporter application enables users to find real-time arrivals of buses and trains in the Bay Area. It allows users to save their most frequented lines to see all transit options at a glance. It provides a simple interface that displays the remaining time for the three upcoming arrivals for each route at a given station.

Automated Visualization of Public Transportation Time Schedules
Joyce takes a similar approach, encoding public transportation arrival time in terms of circles. He notes that this approach includes geographic information of the stations as well as arrival time information relevant to the user. His intention for this visualization is to constantly and automatically display the optimal means of reaching any point in the network without requiring any user input.

METHODS

The system we developed includes an interactive map and a dropdown menu for station selection, a linear layout of routes and trains, vertical labels and text of waiting time, and a set of simple animations for displaying an entire transit system from the point of view of a single station chosen by users at a specific time.

Input and Map
A map of all the transit stations and their surrounding areas is displayed. Each station is represented by a white circle enclosed by a black border. To select a station, a user can either click on the circle or choose from the dropdown menu in the top left-hand corner of the map. The former is used for people who are more familiar with the geographical location of each station and less familiar with their names, and vice-versa.

Figure 3. Alan Joyce's representation of time as a function of radius. Thin lines imply the estimated arrival time of the vehicle to the stop, denoted as the focal point.

Figure 4. Detail of the interface in which users select their current station.

Routes and Trains
Once a station is selected, the station is labeled in a vertical rectangle that represents the current station. This rectangle is placed on the left of the screen with some space allocated to a border to its left. At the same time, we obtain an abbreviation of the selected station, and query the transit’s API using AJAX to obtain all relevant information.
concerning a transportation network’s schedule in real time. The result of the query will be presented in XML form and includes the following: waiting time, route color, and other information for trains arriving at the station within an hour. As delays happen frequently, the actual waiting time may vary a lot. We regroup the data by its respective direction, retaining only the waiting time and color, and then proceed to store the data locally.

For each direction, there exists a horizontal line perpendicular to the current/selected station, represented by the rails. The names of the trains, which correspond to the train’s direction, are displayed to the left end of the line. On each horizontal line, all trains heading in that direction are placed to the right of the rectangle, according to their waiting time. The leftmost train is the next train arriving, which is closest to the current/selected station (rectangular). Each train is visualized by an oval shape whose color is determined by the color of the line from the transit’s official map, with a black border. The number of lines varies for different stations and different times. The rectangular current/selected station will always cover all the lines so its height is automatically resized by the total height of the chart.

**Time Labels**
The oval representation of each train displays the current waiting time. Perpendicular to the parallel tracks, there is an axis meant to denote time till arrival. The time interval between two markets on the axis is five minutes, and in addition, there is a "one minute" axis right next to the selected station rectangular. The displayed time on the trains are designed for people who want to find out the waiting time of a specific train, and the axes are designed to enable smooth comparison between two markers.

**Animation**
All the trains are moving towards the current/selected stations (to the left) in real time. The displayed waiting time on each trained is also continuously updated every minute. As 20 pixels count towards 1 minute, each train will move towards the left by 1 pixel every three seconds. When a train arrives at the selected station, its border turns white, its label will change from “1 min” to “boarding”, and it starts blinking. After 10 seconds, the train will fade out and disappear, indicating its departure from the current station. We provide some simple interaction for the application: the map can be zoomed in and out or dragged in order to find out a transit station, as some stations are packed closely and cluttered. Since we use AJAX to send information and get data, the webpage does not refresh, so users may switch to any other station at any time, and the visualization will overwrite the previous one instantly.

**DISCUSSION**
To evaluate the effectiveness of our visualization system, we conducted a user study. We presented our visualization system to two sets of users: those with familiar with the BART network and those who are not.

| Would you use this visualization system as a mobile/web application? (48 responses) |
|---|---|---|---|
| Total | Familiar | Unfamiliar | Response |
| 33 | 19 | 14 | Yes, I would use it over current applications. |
| 12 | 5 | 7 | Yes, I would use it in conjunction with regular time schedules. |
| 3 | 1 | 2 | No, I would not use it. |

**Table 1. User feedback.**

We surveyed an even number of people from each group. As a whole, we got generally positive and enthusiastic feedback and comments from both groups. The visualization system was fairly intuitive to members of both groups and most could walk through the system without any explanation.

Despite the overall positive reviews, it is fairly clear that our system needs to cater more towards the needs of those who are unfamiliar with the public transport network. One quick fix could be labels on the map for unfamiliar users to navigate the lines more easily.
Figure 6: Visualization system currently at the 16th St. Mission station.

Figure 7: Visualization system currently at the Montgomery station with a train boarding.
FUTURE WORK
This approach to visualizing public transportation arrivals can be expanded in a variety of directions. The public transport network as a whole could be rendered automatically to provide a more intuitive navigation experience for passengers. Specific to our system, interaction could be included where users can input their desired destination. We could also incorporate the difference between the scheduled and arrival time as an extension to help users plan their trips in advance. Based on user feedback, another neat addition would be to incorporate transit information. Passengers are often confused as to when to switch lines to reach certain destinations and a feature that could do this would be most useful.

CONCLUSION
We have presented a novel visualization system that provides users an overview of a public transportation network in terms of distance as well as arrival time. We allow users the option of comparing time of arrivals between different lines and deciding for themselves which route to take to reach their destinations at a given point in time. We proceeded to evaluate our system with regards to existing applications and feedback from almost all of these users indicates that our visualization system is preferred.

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REFERENCES